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Title of the Invention: Method for Coating Rubber Roll with Fluororesin and Fixing Member

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For: W.L. Gore & Associates, Inc.

9109 Eagle Hills Dr . Las Vegas NV 89134 . ph: 866-722-7990 (toll-free) . fax: 702-973-6009
email: sales@tls-translations.com

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(71) Applicant: 000001007
Canon Inc.
30-2 Shimomaruko 3-chome,
Ota-ku, Tokyo

(72) Inventor: Hideo Kawamoto
c/o Canon Inc.
30-2 Shimomaruko 3-chome,
Ota-ku, Tokyo

(72) Inventor: Masaaki Takahashi
(same address as above)

(72) Inventor: Kazuo Kishino
(same address as above)

(74) Agent: Tadashi Wakabayashi,
Patent Attorney (and 4 others)

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(54) [Title of the Invention] **Method for Coating Rubber Roll with Fluororesin and Fixing Member**

(57) [Summary]

[Object] To provide a method for coating a rubber roll with a fluororesin, whereby firm welding strength is obtained between the fluororesin layer and rubber layer without thermal damage to the rubber layer, and whereby a textured roughness can be provided as desired on the surface of the fluororesin; and a fixing member.

[Means of Achievement] The invention is characterized in that a cylindrical surface transfer member is prepared that has a tubular coating of a fluororesin formed on an inner surface and is

formed from a material with a lower coefficient of thermal expansion than a rubber part of a rubber roller; a rubber roller with a layer comprising a mixture of a fluororesin and a fluorine rubber formed on a surface thereof is inserted therein; and, utilizing the difference in the coefficient of thermal expansion between the rubber roller and the surface transfer member caused by heating, heating and melting are carried out with the fluororesin layer in a compressed state, thereby transferring an inner surface pattern of the surface transfer member, while simultaneously causing the fluororesin layer to move from the surface transfer member to the side of the rubber roller, and welding the rubber layer and fluororesin layer.

[Claims]

[Claim 1] A fluororesin coating method, characterized in that a cylindrical surface transfer member is prepared that has a tubular coating of a fluororesin formed on an inner surface and is formed from a material with a lower coefficient of thermal expansion than a rubber part of a rubber roller; a rubber roller with a layer comprising a mixture of a fluororesin and a fluorine rubber formed on a surface thereof is inserted therein; and, utilizing the difference in the coefficient of thermal expansion between the rubber roller and the surface transfer member caused by heating, heating and melting are carried out with the fluororesin layer in a compressed state, thereby transferring an inner surface pattern of the surface transfer member, while simultaneously causing the fluororesin layer to move from the surface transfer member to the side of the rubber roller, and welding the rubber layer and fluororesin layer.

[Claim 2] The fluororesin coating method according to claim 1, wherein an infrared heater is used as heating means during film formation of the fluororesin by heating and firing, and heat is supplied from outside the surface transfer member.

[Claim 3] The fluororesin coating method according to claim 1, wherein 50% or more infrared light passes through the surface transfer member.

[Claim 4] The fluororesin coating method according to claim 2, wherein infrared absorption is as follows: surface transfer member ≤ fluororesin layer < rubber layer surface (welding boundary).

[Claim 5] The fluororesin coating method according to claim 3, wherein a polyimide tube is used as the surface transfer member.

[Claim 6] The fluororesin coating method according to claim 4, wherein a mandrel is cooled.

[Claim 7] A cylindrical or solid cylindrical fixing member used on a side of a fixing device of an electrophotographic image formation device that is in direct contact with toner, characterized in

that the fluororesin coating method according to any of claims 1 to 5 is used to form a fluororesin at a surface roughness of 5 μm or less based on the ten-point average roughness (Rz).

[Claim 8] A cylindrical or solid cylindrical fixing member used on a drive side of a fixing device of an electrophotographic image formation device, characterized in that that the fluororesin coating method according to any of claims 1 to 5 is used to form a fluororesin at a surface roughness of 2 to 20 μm based on the ten-point average roughness (Rz).

[Detailed Description of the Invention]

[0001]

[Technological Field of the Invention] The present invention relates to a method for forming fluororesin coatings on rubber rollers, and relates to a fixing member for electronic image formation devices such as photocopiers and LBPs.

[0002]

[Prior Art] In the past, methods for forming fluororesin coatings on rubber rollers have involved applying a fluororesin powder and fluororesin dispersion onto a rubber roller on which is formed a layer composed of a mixture of fluororesin rubber and fluororesin, and then carrying out heating and firing. When heating and firing the above fluororesin, the fluororesin is heated to at least the melting point of the fluororesin, thereby performing firing and film formation. The inventors of the present invention also have offered a method in which, during firing and film formation of the fluororesin, the fluororesin is heated while simultaneously applying pressure with a surface transfer member disposed on the outside of the elastic body and fluororesin, thereby causing the surface texture on the surface transfer member to be transferred to the fluororesin surface.

[0003] In addition, in JP (Kokoku) 3-12543, a method is provided in which the fluororesin coating material is dried on the surface of a metal cylinder, and is then fired to form a cured coating of fluororesin, whereupon the inner surface of the cured coating is subjected to an etching treatment. After inserting a mandrel, silicone rubber is injected between the coating and the mandrel and thermally cured, before releasing the material to form a fluororesin layer on the silicone rubber base layer.

[0004] In addition, products produced by forming a film of fluororesin as a toner release layer on the outer circumference of an elastic layer formed on a metal base material are often used as

fixing members for electrophotographic image formation devices. In addition, there have recently been cases in which members have been used that are produced by forming an elastic layer on a heat-resistant resin base material, and then forming a fluororesin coating as a toner release layer on the external circumferential surface thereof.

[0005]

[Problems to Be Solved by the Invention] However, the following problems have occurred with the above conventional fluororesin coating methods.

[0006] First, when the fluororesin is coated onto the elastic body and fired under heating, the melt viscosity of the fluororesin is extremely high, and so the evenness of the filmed fluororesin layer will be low, even if heating and firing are carried out at a temperature that is higher than the melting point of the fluororesin. In addition, when the above type of fluororesin baking conditions are used, because the elastic body cannot withstand the temperatures, significant damage to the elastic body results.

[0007] In addition, methods are used in which a cured fluororesin coating is formed on the inner surface and the inner surface is etched, whereupon liquid silicone rubber is injected between the cured fluororesin coating and a mandrel, followed by thermal curing to affix the fluororesin onto the silicone rubber base layer. Although damage to the silicone rubber is controlled with these methods, adhesion between the fluororesin layer and the silicone rubber base layer will not provide sufficient adhesive strength, because adhesion occurs via an adhesive layer. Moreover, maintaining strength is difficult in locations where heat is continually applied, such as with fixing rolls, and there is the problem that the strength is lost due to degradation during long-term use. In addition, as a result, wrinkles or the like are generated and evenness is compromised, leading to breakdown. With methods in which the reactivity is improved by etching the inner surface of the fluororesin to bring about adhesion, special chemicals and equipment is required, which also increases costs. Moreover, the treated surface is influenced by factors such as its environment, and undergoes degradation over time. In forming the silicone rubber base layer, it is also necessary to use liquid silicone rubber, and there is the disadvantage that high-viscosity silicone rubber such as millable-type rubbers cannot be used in the above methods.

[0008] With the objective of resolving the above problems, the present inventors have provided a method in which a fluororesin layer is heated and compressed between a surface transfer member disposed on the outside of the fluororesin and elastic body, thereby transferring the surface

texture of the surface of the surface transfer member to the fluororesin surface while heating and firing to form a fluororesin film. As a result, it is possible to form a film from fluororesin at a lower temperature than in the past, while also controlling the surface texture of the fluororesin. It is thus possible to control damage to the underlying rubber. However, it has not been possible to completely control rubber damage, even when such a method has been used.

[0009] Fluororesins are frequently used for surface layers in order to provide toner release properties in fixing rolls, fixing films, press rolls, and the like, which are used as fixing members in electrophotographic image formation devices.

[0010] In addition, in order to fix up to four layers of toner, if the fluororesin layer which is the surface toner release layer is not flexible so as to allow it to follow the unevenness of the toner or recording material, then heat will not be completely transferred the toner, resulting in the problem that fixing of the toner to the recording material will be poor. For this reason, investigations have been carried out regarding the use of a fixing member having a structure in which a flexible elastic layer is provided as a layer underneath the fluororesin layer used as the toner release layer. However, fairly high temperatures have been required in the past in order to bake fluororesins, and there have been problems with significant damage to the rubber layer underneath the fluororesin. As a result, the C-set of the elastic layer has been compromised, and paper transfer which is required of fixing members has not been possible. Moreover, when the firing temperature of the fluororesin has been decreased in order to suppress this damage, there has been the problem that the fluororesin has not been completely fused, resulting in the generation of cracks and inability to obtain the desired surface properties.

[0011] It is an object of the present invention to provide a fixing member and fluororesin coating method for forming a fluororesin layer on a novel rubber roller, whereby the above problems are solved.

[0012]

[Means Used to Solve the Above-Mentioned Problems] The aforesaid object is achieved by the means described hereunder.

[0013] Specifically, the present invention comprises a fluororesin coating method, characterized in that a cylindrical surface transfer member is prepared that has a tubular coating of a fluororesin formed on an inner surface and is formed from a material with a lower coefficient of thermal expansion than a rubber part of a rubber roller; a rubber roller with a layer comprising a

mixture of a fluororesin and a fluorine rubber formed on a surface thereof is inserted therein; and, utilizing the difference in the coefficient of thermal expansion between the rubber roller and the surface transfer member caused by heating, heating and melting are carried out with the fluororesin layer in a compressed state, thereby transferring an inner surface pattern of the surface transfer member, while simultaneously causing the fluororesin layer to move from the surface transfer member to the side of the rubber roller, and welding the rubber layer and fluororesin layer; the above fluororesin coating method, wherein an infrared heater is used as heating means during film formation of the fluororesin by heating and firing, and heat is supplied from outside the surface transfer member; the above fluororesin coating method, wherein 50% or more infrared light passes through the surface transfer member; the above fluororesin coating method, wherein infrared absorption is as follows: surface transfer member ≤ fluororesin layer < rubber layer surface (thermal welding interface); the above fluororesin coating method, wherein a polyimide tube is used as the surface transfer method; and the above fluororesin coating method, wherein a mandrel is cooled.

[0014] In addition, the present invention offers a cylindrical or solid cylindrical fixing member used on a side of a fixing device of an electrophotographic image formation device that is in direct contact with toner, characterized in that a fluororesin is formed at a surface roughness of 5 μm or less based on the ten-point average roughness (Rz). The above fluororesin coating method provides a cylindrical or solid cylindrical fixing member used on a drive side of a fixing device of an electrophotographic image formation device, characterized in that that a fluororesin is formed at a surface roughness of 2 to 20 μm based on the ten-point average roughness (Rz).

[0015] The method for forming a fluororesin layer on the rubber roller in the present invention involves inserting a rubber roller with a layer formed from a mixture of fluororubber and fluororesin formed on its surface into a cylindrical surface transfer member produced by applying an aqueous paint of a fluororesin onto the inner surface thereof. By utilizing the difference in coefficient of thermal expansion between the base material and the surface transfer member, the fluororesin layer is transferred to the rubber roller surface from the surface transfer member, and the fluororesin layer is thermally welded simultaneously therewith. As a result, thermal damage to the rubber layer is controlled more than in the past, and a firm welding force is achieved between the fluororesin layer and rubber layer.

[0016] In addition, the fluororesin layer of the base material surface layer is more effectively heated using an infrared heater as the heating method during compression and heating from outside the surface transfer member, and thus the surface texture of the surface transfer member is transferred to the fluororesin surface layer while minimizing thermal damage to the base layer. This method also allows the desired texture and roughness to be provided on the surface of the fluororesin, the control of which in regard to surface texture and roughness control having been difficult in the past.

[0017]

[Practical Embodiment of the Invention] The present invention shall be described in further detail below.

[0018] According to the present invention, the cylindrical surface transfer member has a desired texture on its inner surface, and has an inner diameter such that a rubber roller can be inserted. The material has no particular restrictions, provided that it can withstand the temperatures required for firing and filming of the fluororesin, but a metal material such as steel, stainless steel or aluminum, or a heat-resistant resin such as polyimide or polyphenyl sulfide is preferable to use.

[0019] In addition, preheating and firing of the fluororesin layer that is formed on the inner surface of the cylindrical surface transfer member can be carried out until the fluororesin is completely turned into a film, but this is not particularly necessary, as it is sufficient to heat the fluororesin to the fusion temperature. At this time, cracks or nonuniformities may be present on the fluororesin layer. In addition, in the step in which heat and pressure are applied with the fluororesin between the rubber roller and surface transfer body after pre-firing, the temperature of the fluororesin layer has no particular restrictions, provided that it is 200°C or greater, and it is not necessary to increase the temperature to the firing temperature, although heating to 240 to 290°C is preferred. When such a method is used, the fluororesin layer is welded to the rubber roller while minimizing thermal degradation of the base material, and the desired surface pattern can also be provided on the fluororesin surface layer. In addition, because it is not necessary to heat the fluororesin layer to a high temperature during heating and compression, work efficiency is favorable, and the weight of the equipment such as the compression device can be reduced. The material for the surface transfer body has no particular restrictions, as described above.

[0020] Because the thermal expansion coefficient of the rubber roller is greater than that of the surface transfer member, when heating of the surface transfer member is carried out externally using infrared light with the roller inserted into the fluororesin-coated surface transfer member, the thermal expansion of the rubber roller will be greater than that of the surface transfer member. Consequently, the fluororesin layer will be compressed and welded between the rubber roller and surface transfer member, thereby transferring the inner surface texture of the surface transfer roll to the surface of the fluororesin.

[0021] The fluororesin firing and filming temperature is extremely high when the fluororesin is applied to the rubber roller and firing is carried out to form a film, which causes thermal degradation in the rubber. In addition, if the bake-filming temperature is reduced or the fluororesin bake-filming time is reduced in order to prevent thermal degradation of the rubber, the fluororesin will be incompletely formed into a film, and cracks or nonuniformities will arise in the surface, making it extremely difficult to form the desired pattern in the fluororesin surface.

[0022] However, there are methods in which a fluororesin is heated and welded between a rubber roller and a surface transfer member by external heating applied to the surface transfer member using an infrared heater, thereby transferring the surface texture of the surface transfer member to the fluororesin surface. When such a method is used, even if the temperature during firing and filming of the fluororesin is set at a lower temperature, direct heating of the surface fluororesin can occur, and superheating is a possibility, which can cause thermal degradation of the rubber at this time. In addition, when a layer composed of a mixture of fluororubber and fluororesin is provided on the surface of a rubber roller, there are cases where the fluororesin layer is welded firmly to the surface of the rubber roller.

[0023] Moreover, if 50% or more of the infrared light passes through the surface transfer member, then the surface transfer member will not be heated to a large extent, and the energy will return to the fluororesin, causing an increase in thermal expansion of the surface transfer member. Consequently, less energy will be used in the transfer of the surface of the surface transfer member to the fluororesin surface, and the desired texture can be formed on the surface of the fluororesin. In short, thermal degradation of the rubber can be additionally suppressed. Moreover, because the absorption of infrared light follows the formula of surface transfer member $\leq$ fluororesin $<$ base layer surface (welding boundary), the welding interface can be directly heated, and the surface of the transfer member can be more efficiently transferred to the

surface of the fluororesin, thereby making it possible to form the desired texture on the surface of the fluororesin.

[0024] When a polyimide thin-layer tube is used as the surface transfer member, repeated use is possible due to the excellent heat resistance and strength of the material when hot, and thus the durability of the surface transfer member is improved, which facilitates handling.

[0025] It is also possible to additionally inhibit thermal degradation of the rubber by cooling the mandrel during heating.

[0026] Moreover, fluororesin is often used as a surface layer for fixing members used in electrophotographic image formation devices in order to provide them with the desired release properties for toner use.

[0027] In particular, with fixing rolls and fixing films in fixing members that are in contact with the toner, it is desirable for the surface layer fluororesin to be smooth in order to prevent gloss variation in the printed images. Gloss variation in printed images appears most prominently with solid images, specifically, when printing color images such as photographs or the like, and occurs as a result of transfer of the surface texture of the surface layer fluororesin of the fixing film or fixing roll onto the surface of the toner image. Based on research performed by the inventors of this invention, it is possible to prevent gloss variation in the above printed images when the surface roughness of the surface fluororesin of the fixing roll or fixing film is 5 μm or less, based on the ten-point average roughness (Rz).

[0028] However, as described above, it is extremely difficult to provide the desired roughness in existing fluororesin surfaces, and, in order to prevent image gloss variation, a technique has been used in which the roughness is controlled by polishing the surface fluororesin of the fixing rolls and fixing films.

[0029] By means of the present invention, it is possible to form the desired texture in the surface fluororesin of fixing rolls and fixing films, while minimizing thermal degradation of the rubber layer of the base material. This is achieved by inserting the fixing roll and fixing film base material on which is formed a surface layer composed of a mixture of fluororubber and fluororesin into a surface-transfer member with an inner surface that has been coated in advance with fluororesin and pre-fired. An infrared heater is then used to apply heat from outside the surface transfer member, thereby compressing and welding the fluororesin between the surface transfer member and the fixing roll and fixing film base material. Specifically, by forming a

texture with a roughness of 5 μm or less on the inner surface of the surface transfer member in advance, the inner surface of the surface transfer member is then transferred to the surface of the fluororesin surface of the fixing film surface layer, and it is thus possible to form a film of fluororesin with the desired roughness of 5 μm or less. As a result, image gloss variation can be prevented.

[0030] There are no particular restrictions on the fixing roll and fixing film base material in the present invention, but a base material having a multilayer structure wherein a heat-resistant rubber such as a silicone rubber or fluororubber is formed on a mandrel is used.

[0031] In addition, as a fixing film base material, a base material with a multilayer structure may also be used in which heat-resistant rubber such as silicone rubber or fluororubber is formed on a film composed of polyimide or other heat-resistant resin, or nickel, iron, or other metal film.

[0032] In the fixing member having the transfer material transport properties required for use as a fixing member, it is necessary for the surface fluororesin of the fixing member to have a roughness that is sufficient to provide transfer material transport capacity. Based on the investigations of the inventors of the present invention, it has been found that the fluororesin surface roughness that is sufficient for transfer material transport is in the range of 2 to 20 μm, as determined based on the ten-point average roughness (Rz). Within this range, optimal surface roughness is determined based on parameters such as the desired transport properties (for example, image formation performance). However, as described above, it has been extremely difficult to form the desired roughness at the surfaces of fluororesins, and it has not been possible to produce fluororesin surface roughness that is matched to the desired transport properties.

[0033] By using the technique of the present invention, a fixing roll and fixing film base material on which a surface layer composed of a mixture of fluororubber and fluororesin has been formed is inserted into a surface transfer member that has been preheated and fired after coating the inner surface in advance with fluororesin. Subsequently, by heating and utilizing the difference in coefficient of thermal expansion of the base material and the surface transfer member, the fluororesin layer is transferred to the rubber roller surface, and, simultaneously therewith, strong welding force is obtained as a result of welding. In addition, it is also possible to transfer the desired texture from the surface transfer member to the surface fluororesin of the fixing film and fixing roll. Moreover, by applying pressure while heating from the outside the surface transfer member using an infrared heater, the desired texture can be formed in the surface fluororesin of

the fixing film and fixing roll while minimizing thermal degradation of the rubber layer of the base material with the fluororesin between the surface transfer member and the fixing roll and fixing film base material. Specifically, by forming a texture with a roughness of 2 to 20 μm or less in advance on the inner surface of the surface transfer member, the inner surface of the surface transfer member is transferred to the fluororesin surface used as the surface layer of the fixing film and fixing roll, thereby allowing filming of fluororesin with the desired surface roughness of 2 to 20 μm or less. As a result, it is possible to endow the fixing member with the desired transfer material transport properties.

[0034]

[Working Examples]

(First working example) A first working example of the present invention will be described in reference to FIG. 1.

[0035] Reference symbol 1A denotes a cylindrical base material used in the working example. A cross-sectional view thereof is presented in FIG. 1(b). 1A-1 is a mandrel for the cylindrical base material, and is formed from SUS. The diameter is 40 mm, and an LTV silicone rubber layer 1A-3 is present at a thickness of 1 mm via a primer layer 1A-2 on the mandrel 1A-1. The above silicone rubber layer was formed by inserting a mandrel coated with primer into a cylindrical mold, and then injecting uncured LTV silicone rubber and heating the material to cure it. Reference symbol 1A-4 is a primer layer for bonding the silicone rubber layer 1A-3 and the surface layer fluororesin layer, and is formed from a mixture of fluororubber and fluororesin (FEP). The primer layer 1A-4 was obtained by spray-coating an aqueous paint composed of a mixture of fluororubber and fluororesin, and then curing by heating for 30 min at 200°C. The thickness was 25 μm. Reference symbol 1B is a surface transfer member pertaining to the present invention produced by applying fluororesin to the inner surface and pre-firing. A cross-sectional view thereof is presented in FIG. 1(c). Reference symbol 1B-1 is a cylindrical surface transfer member with an inner diameter of 42.2 mm and a thickness of 0.05 mm. In this working example, a Ni electrolytic film was used as the material for the surface transfer member. A surface texture to be transferred to the fluororesin surface was formed on the inner surface of this transfer member 1B-1, and, in this working example, the inner surface of the surface transfer member was processed to have a surface roughness of 5 μm. 1B-2 is a fluororesin layer, and was produced by spray-coating dispersion of fluororesin (FEP) onto the inner surface of the surface

transfer member, and drying for 20 min at 150°C, before pre-firing for 20 min at 300°C. The thickness was 15 μm.

[0036] The base material 1A was inserted into the surface transfer member 1B so that the base material and the surface transfer member were aligned along the center lines, and the two were then fixed and integrated with a fixing member not shown in the drawings. At this time, the gap between the fixing base material and the surface transfer member was about 60 μm. The base material and surface transfer member that had been integrated as described above were then heated from the outside of the surface transfer member using an infrared heater 18. In this working example, an infrared heater (collimated type) with an output of 3 kW having a length (300 mm) that was about the same as that of the base material was disposed with a separation of about 50 mm from the surface of the surface transfer member. Heating was performed for about 6 min in this state at 3 kW. At this time, thermal expansion of the silicone rubber constituting the base material was greater than that of the Ni constituting the surface transfer member, and thus silicone rubber expanded more, filling the gap of about 60 μm between the surface transfer member and the base material, thereby producing a condition in which the fluororesin layer was compressed. In addition, the fluororesin (FEP) of the surface layer of the base material was softened by the infrared heat and welded onto the silicone rubber, while the desired surface texture was transferred to the fluororesin surface layer.

[0037] Upon completion of the above process, the base material and the surface transfer member were cooled, and the base material was released from the surface transfer member.

[0038] The roughness of the surface of the fired fluororesin film obtained in this manner was 5 μm in terms of the ten-point average roughness (Rz), and the surface texture of the surface transfer member was transferred to the fluororesin surface, thus producing a fluororesin film. In addition, the surface of the resulting fluororesin layer film was observed with an electron microscope, and no abnormalities such as cracks were observed in the surface. In addition, it was possible to improve production efficiency because the time was dramatically reduced relative to when heating is performed in an oven (about 20 min).

(Second working example) A second working example of the present invention is described below in reference to FIG. 2.

[0039] Reference symbol 2A is a cylindrical base material used in this working example, and a cross-sectional view is presented in FIG. 2(b). Reference symbol 2A-1 is a cylindrical base

material mandrel, and is formed from SUS, with a diameter of 40 mm. An LTV silicone rubber layer 2A-3 was formed on the mandrel 2A-1 via a primer layer 2A-2, and the thickness thereof was 1 mm. The mandrel coated with primer was inserted into a cylindrical mold, and LTV uncured silicone rubber was injected therein and heated to cure it, thereby forming the silicone rubber layer. Reference symbol 2A-4 is a primer layer for adhering the silicone rubber layer 2A-3 and the surface fluororesin layer, and was formed from a mixture of fluororubber and fluororesin (FEP). The above primer layer 2A-4 was obtained by spraying an aqueous coating composed of a mixture of fluororubber and fluororesin to apply it, and then heating and curing it for 30 min at 200°C to produce a thickness of 25 μm.

[0040] Reference symbol 2B is a surface transfer member pertaining to the present invention, produced by applying fluororesin to the inner surface and pre-firing. A cross-sectional view thereof is presented in FIG. 2(c). Reference symbol 2B-1 is a surface transfer member, and was formed as a cylinder with an inner diameter of 42.2 mm and a wall thickness of 0.05 mm. In the present invention, heat-resistant glass was used as the material for the surface transfer member. A surface texture to be transferred to the fluororesin surface was formed on the inner surface of the surface transfer member 2B-1, and, in this working example, the inner surface of the surface transfer member was processed to a surface roughness of 5 μm. In addition, reference symbol 2B-2 is a fluororesin layer with a thickness of 15 μm formed by spraying a dispersion of fluororesin (FEP) onto the inner surface of the surface transfer member, drying of 20 min at 150°C, and then pre-firing for 20 min at 300°C.

[0041] The base material 2A was inserted into the surface transfer member 2B so that the base material and the surface transfer member were aligned along the center lines, and the two were then fixed and integrated with a fixing member not shown in the drawings. At this time, the gap between the fixing base material and the surface transfer member was about 60 μm. The base material and surface transfer member that had been integrated as described above were then heated from outside the surface transfer member using an infrared heater 18. In this working example, an infrared line heater (collimated type) with an output of 3 kW having a length (300 mm) that was about the same as that of the base material was disposed with a separation of about 50 mm from the surface of the surface transfer member. Heating was performed for about 6 min in this state at 3 kW. At this time, thermal expansion of the silicone rubber constituting the base material was greater than that of the polyimide constituting the

surface transfer member, and thus the silicone rubber expanded more, filling the gap of about 60 μm between the surface transfer member and the base material, thereby producing a state in which the fluororesin layer was compressed. In addition, the fluororesin (FEP) of the surface layer of the base material was softened by the infrared heat, thereby filmed it on the silicone rubber, while also transferring the desired surface texture to the fluororesin surface layer.

[0042] Upon completion of the above process, the base material and the surface transfer member were cooled, and the base material was released from the surface transfer member.

[0043] The roughness of the surface of the fired fluororesin film obtained in this manner was 5 μm in terms of the ten-point average roughness (Rz), and the surface texture of the surface transfer member was transferred to the fluororesin surface, thus producing a fluororesin film. In addition, the filmed fluororesin layer surface was observed with an electron microscope, and no abnormalities such as cracks were observed in the surface. Of course, rubber degradation during welding of the fluororesin onto the silicone rubber was also prevented.

[0044] However, it was difficult to process the heat resistant glass so that the inner diameter was precisely cylindrical, and because the material was easily broken, it was not well suited to mass production due to tendency for damage when repeatedly heated and cooled.

(Third working example) The third working example of the present invention will be described in reference to FIG. 3.

[0045] Reference symbol 3A presents a cylindrical base layer used in this working example, and a cross-sectional view thereof is presented in FIG. 3(b). Reference symbol 3A-1 is a mandrel for the cylindrical base material, and was formed from stainless steel with a diameter of 40 mm. An LTV silicone rubber layer 3A-3 was affixed to the mandrel 3A-1 via a primer layer 3A-2, and the thickness thereof was 1 mm. The mandrel coated with primer was then inserted into a cylindrical mold, and LTV uncured silicone rubber was injected therein and heated to cure it, thereby forming a silicone rubber layer. Reference symbol 3A-4 is a primer layer for bonding the silicone rubber layer 3A-3 and the surface fluororesin layer, and was formed from a mixture of fluororubber and fluororesin (FEP). The above primer layer 3A-4 was obtained by spraying an aqueous coating composed of a mixture of fluororubber and fluororesin to apply it, and then heating and curing it for 30 min at 200°C to produce a thickness of 25 μm.

[0046] Reference symbol 3B is a surface transfer member pertaining to the present invention, produced by applying fluororesin to the inner surface and pre-firing. A cross-sectional view

thereof is presented in FIG. 3(c). Reference symbol 3B-1 is the surface transfer member, and is formed as a cylinder with an inner diameter of 42.2 mm and a wall thickness of 0.05 mm. In the present invention, a polyimide film was used as the material for the surface transfer member. A surface texture to be transferred to the fluororesin surface was formed on the inner surface of the surface transfer member 3B-1, and, in this working example, the inner surface of the surface transfer member was processed to a surface roughness of 5 μm. In addition, 3B-2 is a fluororesin layer with a thickness of 15 μm formed by spraying a dispersion of fluororesin (FEP) onto the inner surface of the surface transfer member, drying for 20 min at 150°C, and then pre-firing for 20 min at 300°C.

[0047] The base material 3A was inserted into the surface transfer member 3B so that the base material and the surface transfer member were aligned along the center lines, and the two were then fixed and integrated with a fixing member not shown in the drawings. At this time, the gap between the base material and the surface transfer member was about 60 μm. The base material and surface transfer member that had been integrated as described above were then heated from outside the surface transfer member using an infrared heater 18. In this working example, an infrared line heater (collimated type) with an output of 3 kW having a length (300 mm) that was about the same as that of the base material was disposed with a separation of about 50 mm from the surface of the surface transfer member. Heating was performed for about 6 min in this state at 3 kW. At this time, the thermal expansion of the silicone rubber constituting the base material was greater than that of the polyimide constituting the surface transfer member, and thus the silicone rubber expanded more, filling the gap of about 60 μm between the surface transfer member and the base material, thereby producing a state in which the fluororesin layer was compressed. In addition, the fluororesin (FEP) of the surface layer of the base material was softened by the infrared heat, thus resulting in a film formed on the silicone rubber while also transferring the desired surface texture to the fluororesin surface layer.

[0048] Upon completion of the above process, the base material and the surface transfer member were cooled, and the base material was released from the surface transfer member.

[0049] The roughness of the surface of the fired fluororesin film obtained in this manner was 5 μm in terms of the ten-point average roughness (Rz), and the surface texture of the surface transfer member was transferred to the fluororesin surface, thus producing a fluororesin film. In addition, the surface of the fluororesin layer film was observed with an electron microscope, and

no abnormalities such as cracks were observed in the surface. It shall be apparent that rubber degradation during welding of the fluororesin onto the silicone rubber was also prevented.

[0050] The polyimide film can be precisely and readily produced by means of producing a master having the desired surface precision, applying the polyimide thereto, and curing it. In addition, because the material has strength at high temperatures, durability over repeated use can be improved in the surface transfer member. Moreover, because of its flexibility, it is easy to handle and amenable to mass production.

(Fourth working example) The fourth working example of the present invention will be described in reference to FIG. 4.

[0051] When processing under the same conditions as in Working Example 3, cooling air 69 at –10°C was made to flow at a flow rate of 1 L per minute into the center of the mandrel for a total of 10 min, from 5 min prior to irradiation with infrared light to 5 min after irradiation. As a result, the base material and surface transfer member were cooled for a period of 10 min from before to after heating, thereby reducing the time required to release the base material from the surface transfer member. A fired fluororesin film was similarly obtained up to this point, with the exception that the output of the infrared light was 3.5 kW, and irradiation was performed for 2.5 min. The roughness of the surface was 4.8 μm as determined by the ten-point average roughness (Rz). The surface texture of the surface transfer member was thus transferred to the fluororesin surface, thus producing a fluororesin film. In addition, the surface of the fluororesin layer that had been filmed was observed with an electron microscope and no abnormalities such as cracks were observed in the surface.

[0052] Of course, rubber degradation did not occur during welding of the fluororesin to the silicone rubber. In short, the time required up to removal from the mold was somewhat shorter than in Working Example 3.

(Fifth working example) A fixing roll for color image forming devices was produced by the same method as in the third working example.

[0053] A cross-sectional view of the fixing roll used in color image formation devices is presented in FIG. 5. Reference symbol 5A-1 is an aluminum mandrel for the fixing roll, and has a diameter of 58 mm. By the same method as in the third working example, a silicone rubber primer layer 5A-2, a 1-mm silicone rubber layer 5A-3 and a 25-mm primer layer 5A-4 formed from a mixture of fluororubber and fluororesin were formed on this mandrel.

[0054] The above fixing roll was inserted and fixed in a surface transfer member having the form of a cylinder with an inner diameter of 60.2 mm and a wall thickness of 0.05 mm formed from polyimide with fluororesin 5A-5 applied and pre-fired on the inner surface. The materials were integrated, and were heated for about 3 min with an infrared line heater (collimated type) having an output of 3 kW and a length (300 mm) that was about the same as the base material, situated at a distance of about 50 mm from the surface of the surface transfer member from outside the surface transfer member. At this time, the surface roughness of the inner surface of the surface transfer member was, based on the 10-point average roughness (Rz), 10 μm (Working Example 5.1), 5 μm (working Example 5.2), or 2 μm (Working Example 5.3). Fixing rolls were thus produced under the respective parameters described above. The results for the surface roughness and fixing roll evaluations carried out on fixing rolls produced using these surface transfer members are presented in Table 1.

[0055] Based on these results, it was determined that the desired roughness could be produced in the fluororesin surface by adjusting the surface roughness of the surface transfer member. In addition, regarding image gloss variation which has been a problem in color image formation devices, the problem was solved by using the above method to adjust the surface roughness of the fluororesin.

[0056]

[Table 1]

	Surface transfer member surface roughness Rz (μm)	Fixing roll surface roughness Rz (μm)	Image evaluation gloss variation
Comparative Example 1	No surface transfer process	15.2	
Working Example 5.1	10.0	10.3	△
Working Example 5.2	5.0	4.8	O
Working Example 5.3	2.0	2.2	O

O: No gloss variation
△: Partial gloss variation
×: Gloss variation

(6th working example) By the same method as in the third working example, a press roll for image formation devices was produced for a press roll-drive film fixing format.

[0057]

FIG. 6 shows a cross-sectional view of the press roll used in the device having a press-roll-driven film-fixing configuration. Reference symbol 6A-1 is an aluminum mandrel for the

fixing roll, and had a diameter of 10 mm. Using the same method as in the third working example, a silicone rubber primer layer 6A-2, a 3-mm silicone rubber layer 6A-3, and a 25-μm primer layer 6A-4 formed from a mixture of fluororubber and fluororesin were formed on the mandrel. A dispersion of fluororesin (FEP) was sprayed onto the inner surface of the surface transfer member in advance, and, after drying for 20 min at 150°C, was pre-fired for 20 min at 300°C to form a fluororesin layer 6a-5. The thickness at this time was 15 μm. The fixing roll had an inner diameter of 16.6 mm and a wall thickness of 0.05 mm, and, by means of the above method, the roll was inserted and fixed to integrate it on the interior of a surface transfer member formed from polyimide that had been produced in the form of a cylinder, with the fluororesin layer formed on the interior surface. The cylinder was heated for about 3 min with an infrared line heater (collimated type) having an output of 3 kW and a length (300 mm) that was about the same as the base material, situated at a distance of about 50 mm from the surface of the surface transfer member from outside the surface transfer member. At this time, the surface roughness of the inner surface of the surface transfer member was, based on the 10-point average roughness (Rz), 25 μm (Working Example 6.1), 10 μm (Working Example 6.2), or 5 μm (Working Example 6.3). Fixing rolls were thus produced under the respective parameters described above. The results for the surface roughness and press roll evaluations carried out on the press rolls produced using these surface transfer members are presented in Table 2. Based on these results, it was determined that the desired roughness could be produced in the fluororesin surface by adjusting the surface roughness of the surface transfer member. In addition, problems regarding transfer material transport properties and image problems in press-roll-driven film-fixing devices can be solved by using the above method to control the surface roughness of the fluororesin tube.

[0058]

[Table 2]

	Surface transfer member surface roughness Rz (μm)	Press roll surface roughness Rz (μm)	Transport properties	Image evaluation: Image disruption
Comparative Example 2	No surface transfer process	13.9	△	O
Working Example 6.1	25.0	23.3	O	×
Working Example 6.2	10.0	9.3	O	O
Working Example 6.3	5.0	5.3	O	O

O : No gloss variation
△: Partial gloss variation
×: Gloss variation

[0059]

[Effect of the Invention] As described above, it was possible, by means of the following method, to endow the surface of fluororesin with any desired texture and roughness, which has been difficult to control in the past. A rubber roller produced by baking and forming a film from a layer composed of a mixture of fluororubber and fluororesin on its surface was inserted into a cylindrical surface transfer member produced by applying an aqueous paint of fluororesin (e.g., FEP, PFA, PTFE) onto its inner surface, followed by firing and the forming of a film by preheating. Next, under applied heat and pressure, the fluororesin layer was firmly affixed while compressing and fusing it, allowing the surface texture of the surface transfer member to be transferred to the surface of the fluororesin layer. The heating method used at this time was an infrared heater, and because the fluororesin layer on the inner surface of the surface transfer member could be more effectively heated by means of heating from outside the surface transfer member using an infrared heater, it was possible to transfer the surface texture of the surface transfer member without thermal degradation of the base-layer rubber material.

When the above method was used in the production of a fixing member used for direct contact with toner in fixing deices for image formation devices, it was possible to control the surface roughness of the surface layer fluororesin. Gloss variation in the image could also be prevented.

[0060] In addition, when the above method was used in the production of a fixing member used on the drive side of fixing devices for image formation devices, the surface roughness of the

surface-layer fluororesin could be controlled, and problems with image disruption and transport characteristics could also be prevented.

[Brief Description of the Drawings]

[Figure 1] FIG. 1(a) is a schematic view of the fluororesin coating method of Working Example 1; FIG. 1(b) is a cross-sectional view of the cylindrical base material of Working Example 1; and FIG. 1(c) is a cross-sectional view of the surface transfer member subsequent to the formation of the fluororesin layer of Working Example 1.

[Figure 2] FIG. 2(a) is a schematic view of the fluororesin coating method of Working Example 2; FIG. 2(b) is a cross-sectional view of the cylindrical base material of Working Example 2; and FIG. 2(c) is a cross-sectional view of the surface transfer member subsequent to formation of the fluororesin layer of Working Example 3.

[Figure 3] FIG. 3(a) is a schematic view of the fluororesin coating method of Working Example 3; FIG. 3(b) is a cross-sectional view of the cylindrical base material of Working Example 3; and FIG. 3(c) is a cross-sectional view of the transfer member subsequent to formation of the fluororesin layer of Working Example 3.

[Figure 4] FIG. 4(a) is a schematic view of the fluororesin coating method of Working Example 4; FIG. 4(b) is a cross-sectional view of the cylindrical base material of Working Example 4; and FIG. 4(c) is a cross-sectional view of the transfer member subsequent to formation of the fluororesin layer of Working Example 4.

[Figure 5] Cross-sectional view of the fixing roll of Working Example 5

[Figure 6] Cross-sectional view of the fixing roll of Working Example 6

[Key]

1A, 2A, 3A, 4A: Base material

1B, 2B, 3B, 4B: Fluororesin layer forming agent inner surface transfer member

1A-1, 2A-1, 3A-1, 4A-1, 5A-1, 6A-1: Mandrel

1A-2, 2A-2, 3A-2, 4A-2, 5A-2, 6A-2: Silicone primer layer

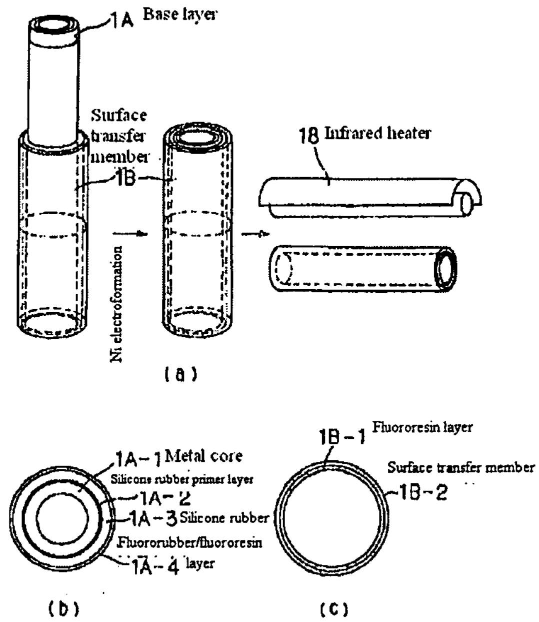
1A-3, 2A-3, 3A-3, 4A-3, 5A-3, 6A-3: Silicone rubber layer

1A-4, 2A-4, 3A-4, 4A-4, 5A-4, 6A-4: Fluororubber/fluororesin

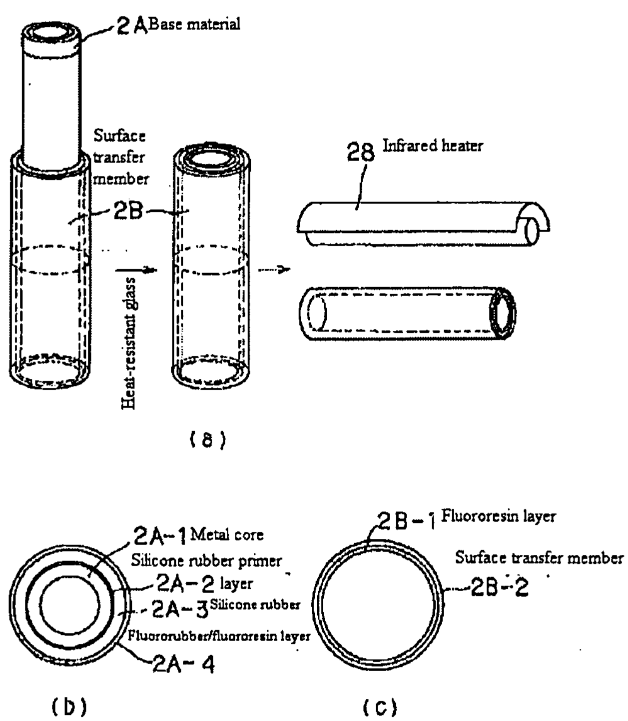
1B-1, 2B-1, 3B-1, 4B-1, 5A-5, 6A-5: Fluororesin layer

1B-2, 2B-2, 3B-2, 4B-2, 5B-2, 6B-2: Surface transfer member

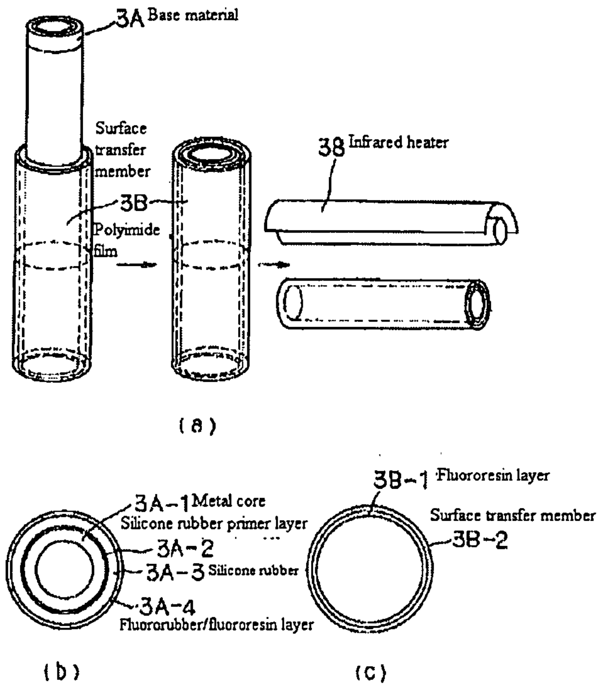
18, 28, 38, 48: Infrared heater



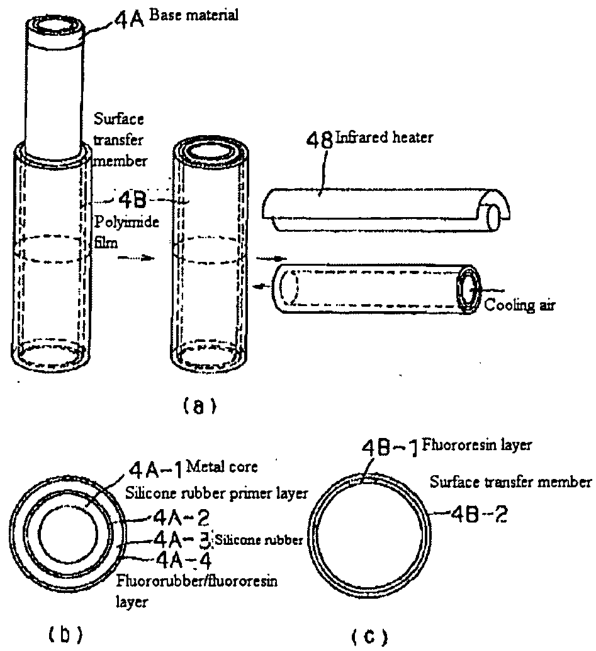
[FIG. 1]



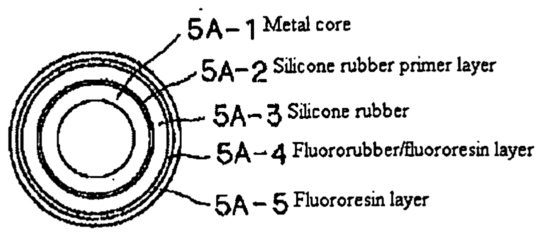
[FIG. 2]


3A Base material
Surface transfer member
3B
Polyimide film
38 Infrared heater
(a)
3A-1 Metal core
Silicone rubber primer layer
3A-2
3A-3 Silicone rubber
3A-4
Fluororubber/fluororesin layer
3B-1 Fluororesin layer
Surface transfer member
3B-2
(b)
(c)

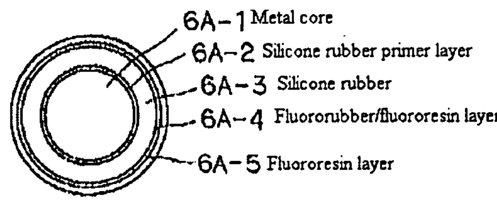
[FIG. 3]


4A Base material
Surface transfer member
4B
Polyimide film
48 Infrared heater
Cooling air
(a)
4A-1 Metal core
Silicone rubber primer layer
4A-2
4A-3 Silicone rubber
4A-4
Fluororubber/fluororesin layer
4B-1 Fluororesin layer
Surface transfer member
4B-2
(b)
(c)

[FIG. 4]



[FIG. 5]



[FIG. 6]

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(72) Inventor: Osamu Saotome
c/o Canon Inc.
30-2 Shimomaruko 3-chome, Ota-ku, Tokyo